US005881345A

United States Patent [19]

Yamane et al.

[11] **Patent Number: 5,881,345**

[45] **Date of Patent: Mar. 9, 1999**

[54] **IMAGE FORMING MACHINE**

[75] Inventors: **Naoki Yamane**; **Koji Shin**, both of Osaka, Japan

[73] Assignee: **Mita Industrial Company, Ltd.**, Osaka, Japan

[21] Appl. No.: **890,395**

[22] Filed: **Jul. 9, 1997**

[30] **Foreign Application Priority Data**

Sep. 7, 1996 [JP] Japan 8-178790

[51] **Int. Cl.**[6] **G03G 15/08**

[52] **U.S. Cl.** **399/255**; 399/359

[58] **Field of Search** 399/254, 255, 399/256, 358, 359, 360

[56] **References Cited**

U.S. PATENT DOCUMENTS

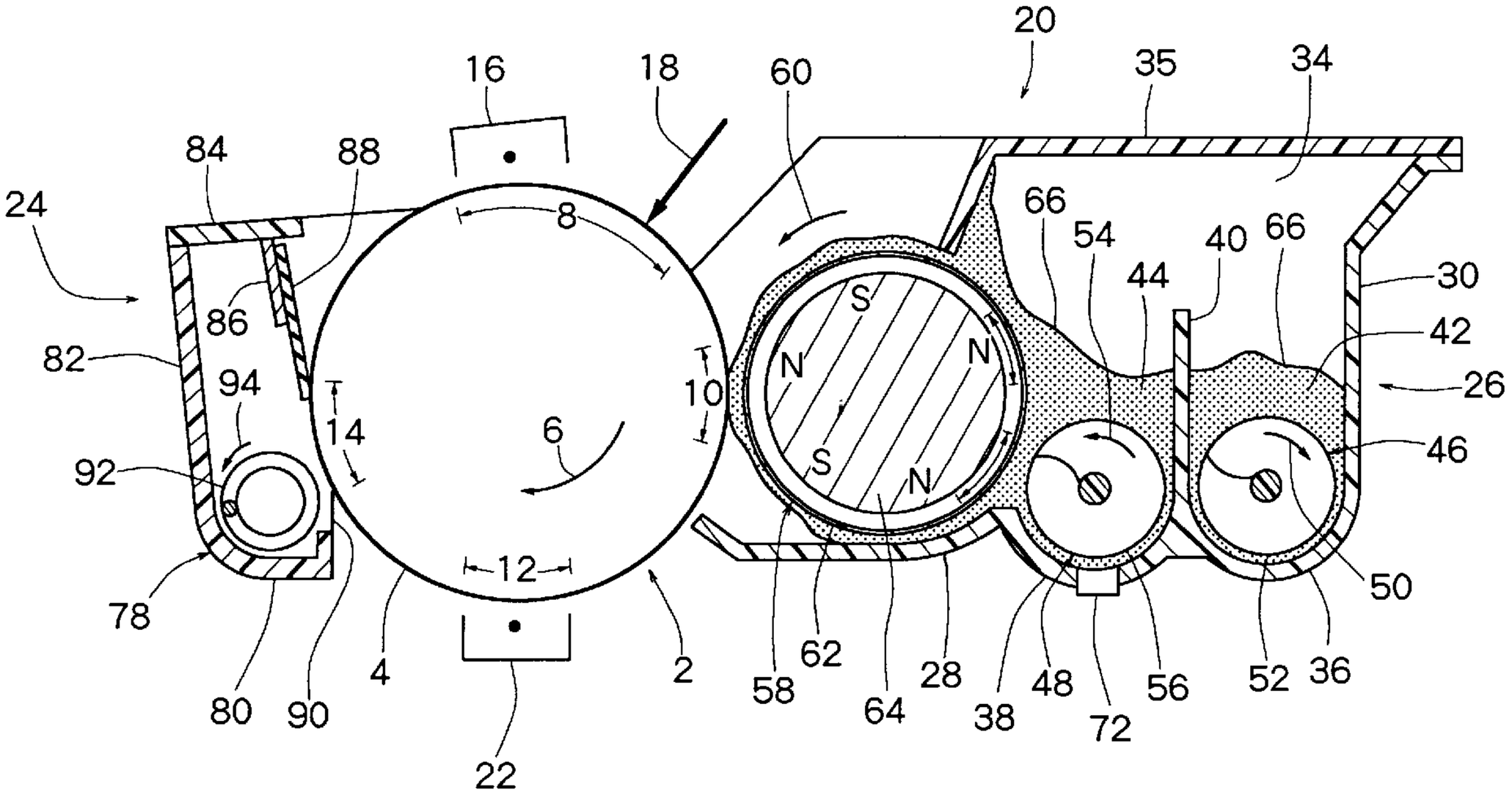
5,592,267 1/1997 Misago et al. ..... 399/359 X

Primary Examiner—Arthur T. Grimley
Assistant Examiner—Hoan Tran
Attorney, Agent, or Firm—Antonelli, Terry, Stout & Kraus, LLP

[57] **ABSTRACT**

An image forming machine, including an image bearing member, a developing unit for developing a latent electrostatic image on the image bearing member into a toner image, a cleaning unit for removing remaining toner from the image bearing member after transfer of the toner image from the image bearing member onto a sheet member, and a toner supply unit for supplying toner to the developing unit. The toner supply unit includes a first toner acceptance region where fresh toner is introduced, a second toner acceptance region where recycled toner, that has been removed from the image bearing member by the cleaning unit, is introduced, a toner discharge region having a toner discharge opening communicating with the developing unit, a first toner conveying member for conveying fresh toner from the first toner acceptance region to the toner discharge region, and a second toner conveying member for conveying recycled toner from the second toner acceptance region to the toner discharge region.

6 Claims, 5 Drawing Sheets



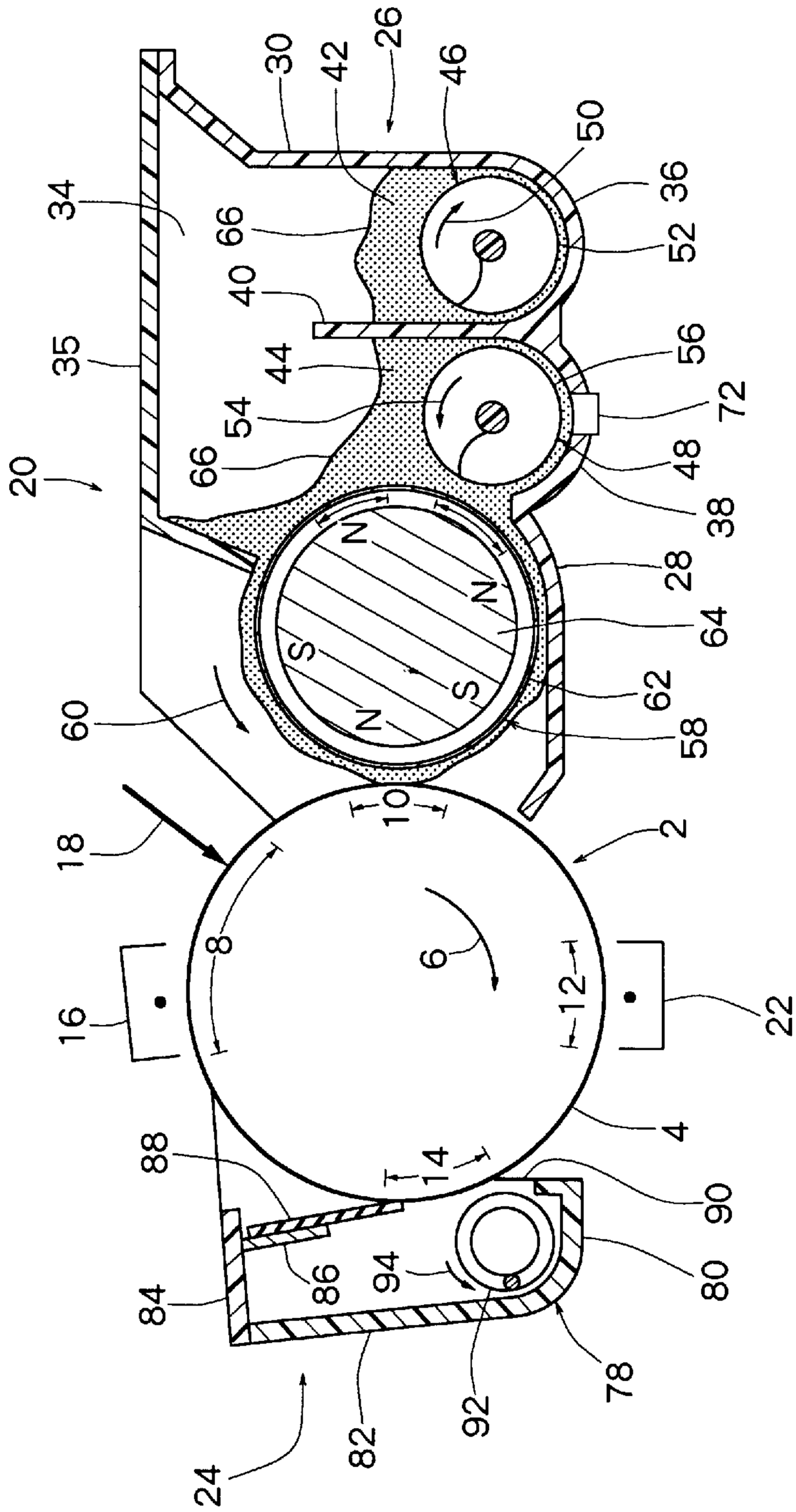

20
18
16
22
24
2
4
6
8
10
12
14
26
28
30
34
35
36
38
40
42
44
46
48
50
52
54
56
58
60
62
64
66
72
80
82
84
86
88
90
92
94
N
S

Fig. 1

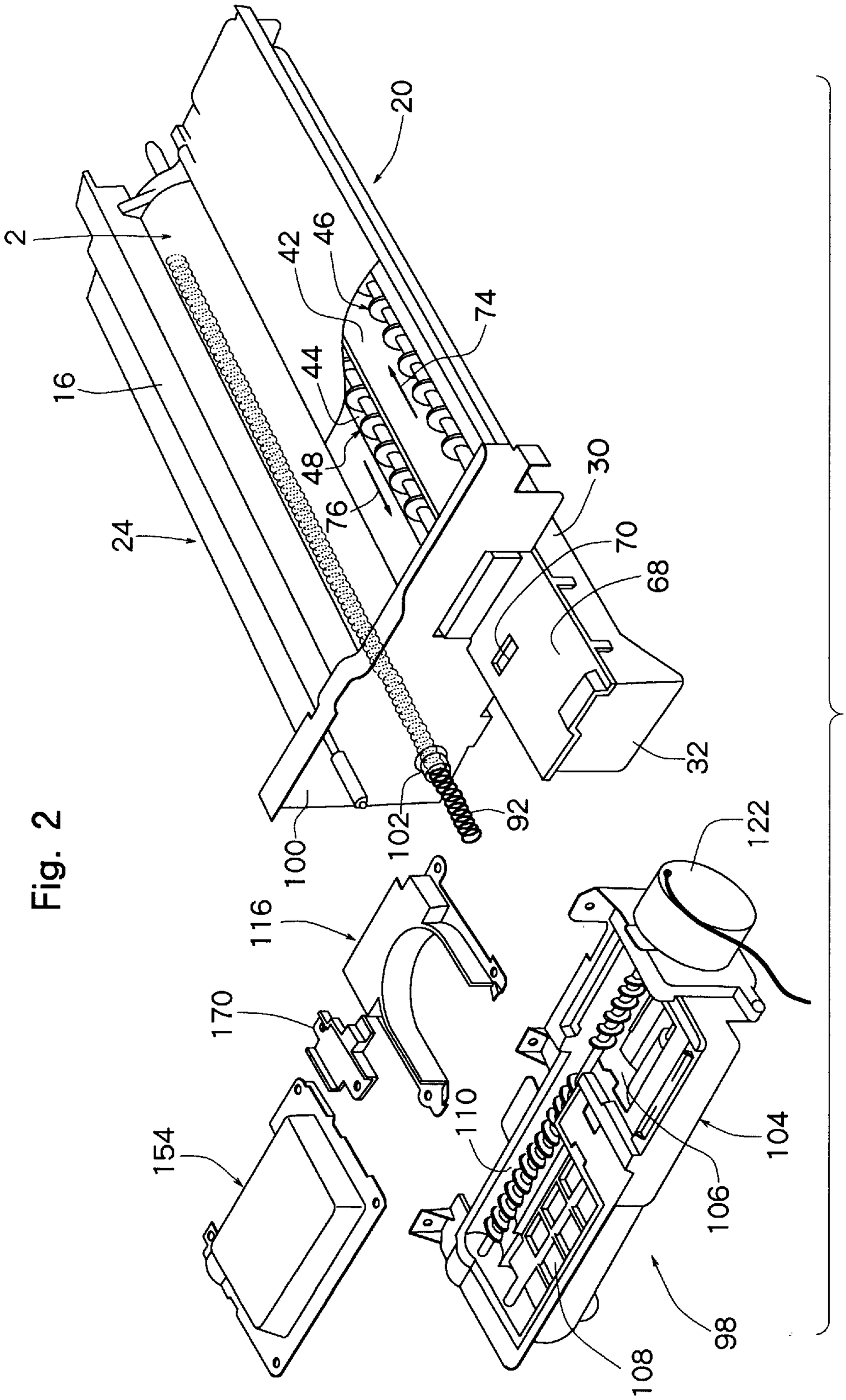

20
2
16
24
42
46
44
48
76
74
30
70
68
32
96
100
102
92
116
170
154
110
122
104
106
108
98

Fig. 2

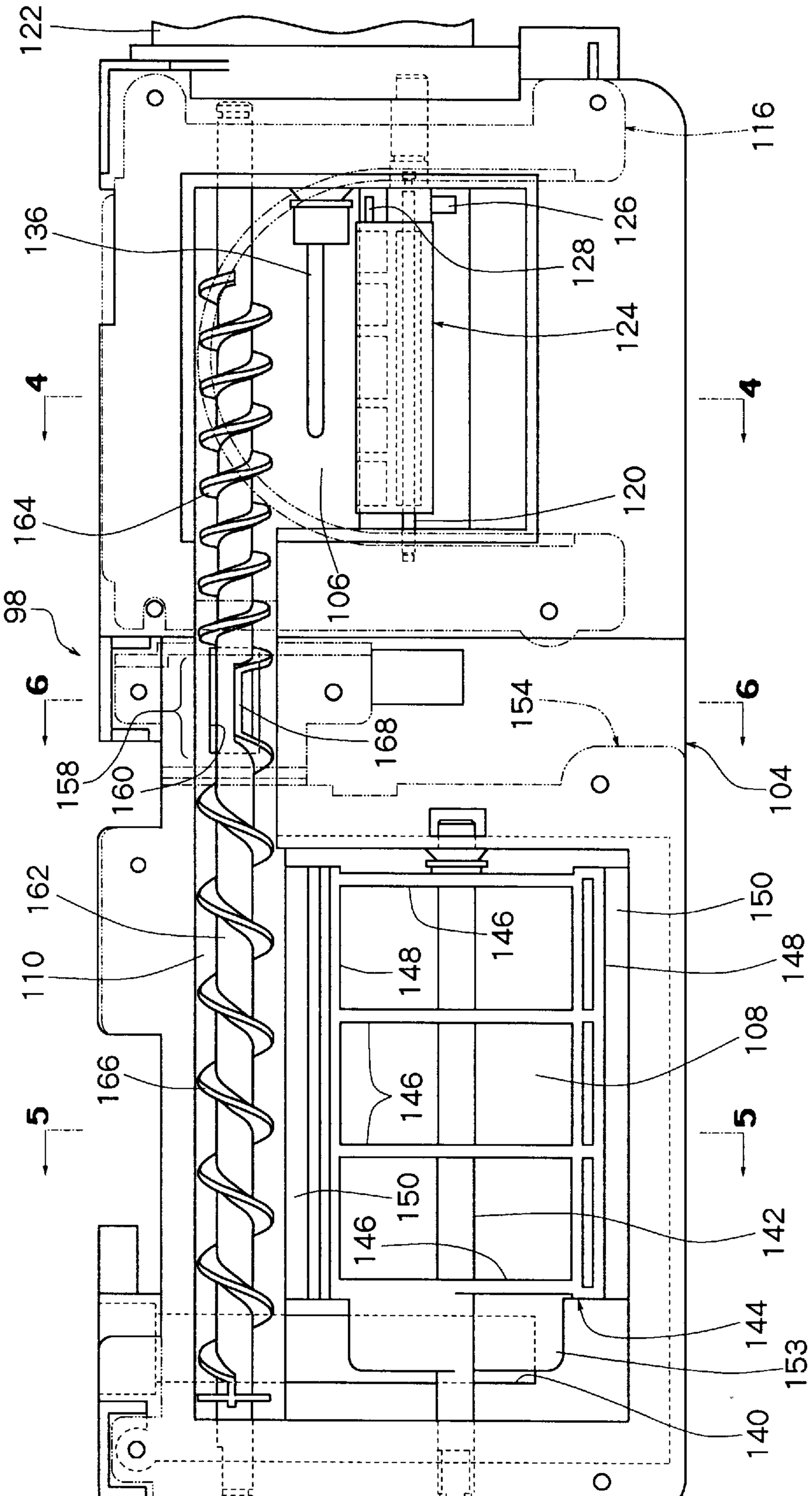

122
116
136
126
128
124
4
4
164
120
106
98
6
6
154
158
160
168
104
162
110
166
150
146
148
108
146
150
146
142
5
5
144
153
140

Fig. 3

Fig. 4

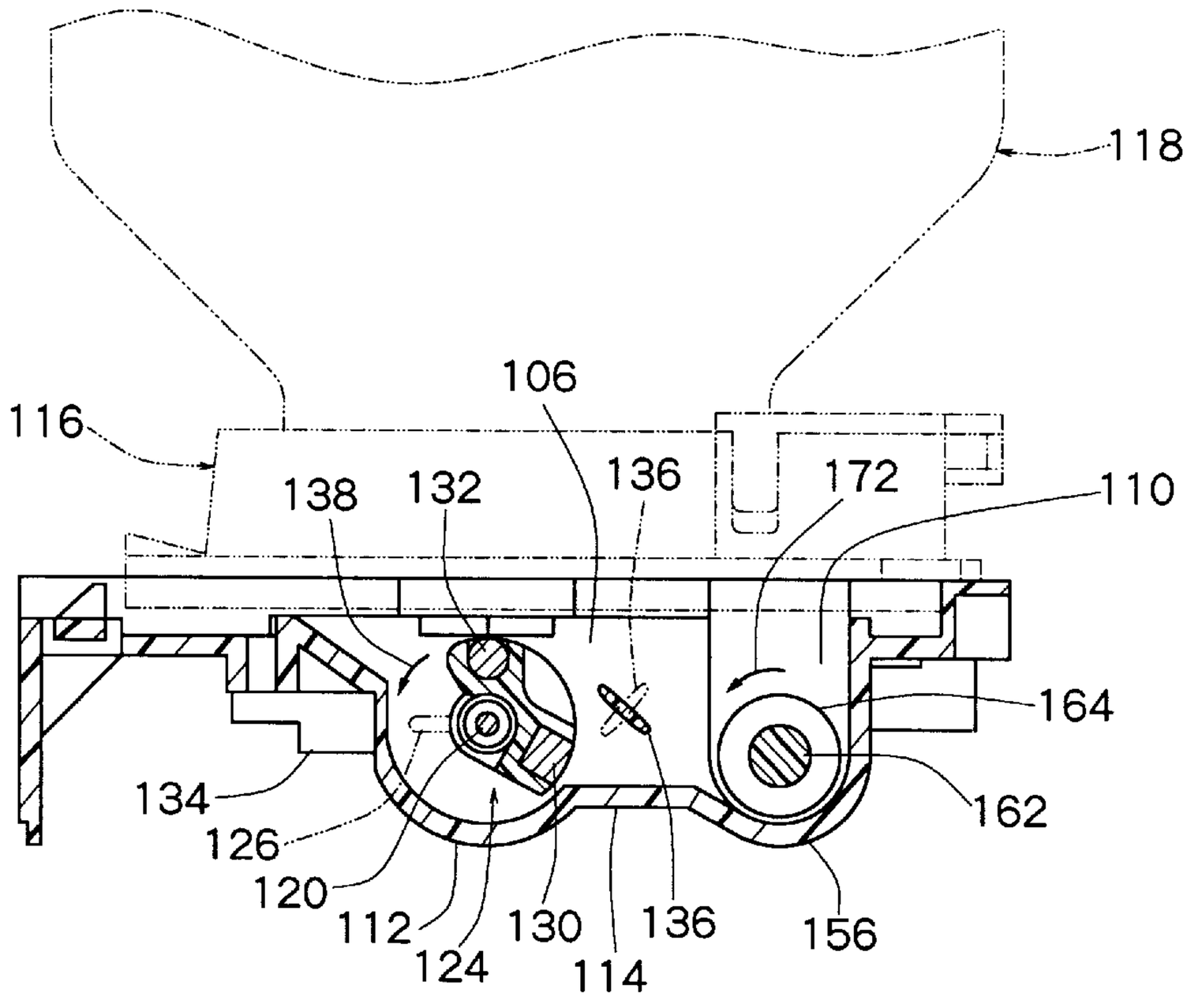

118
106
116
138
132
136
172
110
164
134
126
162
120
112
124
130
114
136
156

Fig. 5

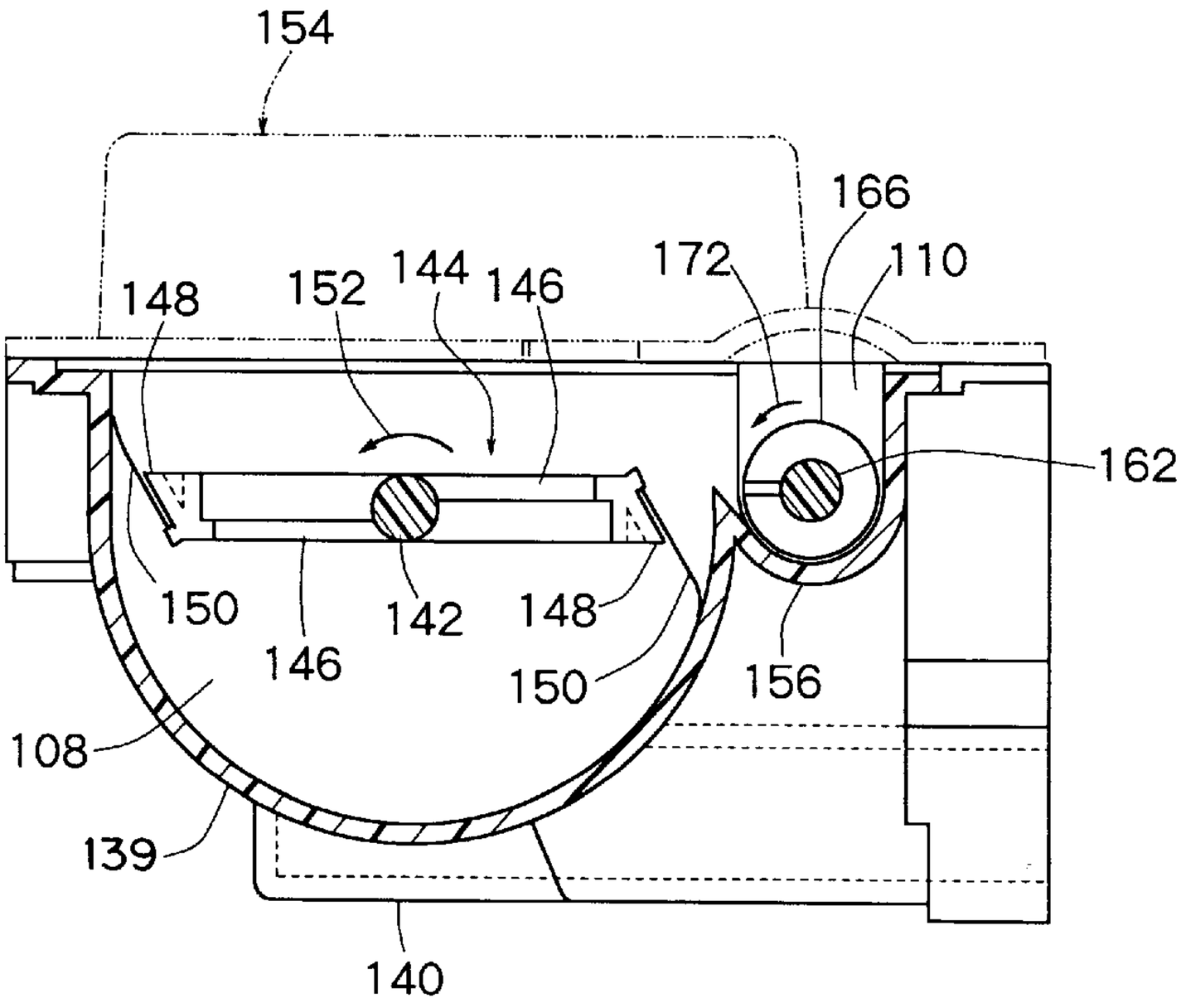

154
166
172
110
148
152
144
146
162
150
142
148
146
150
156
108
139
140

Fig. 6

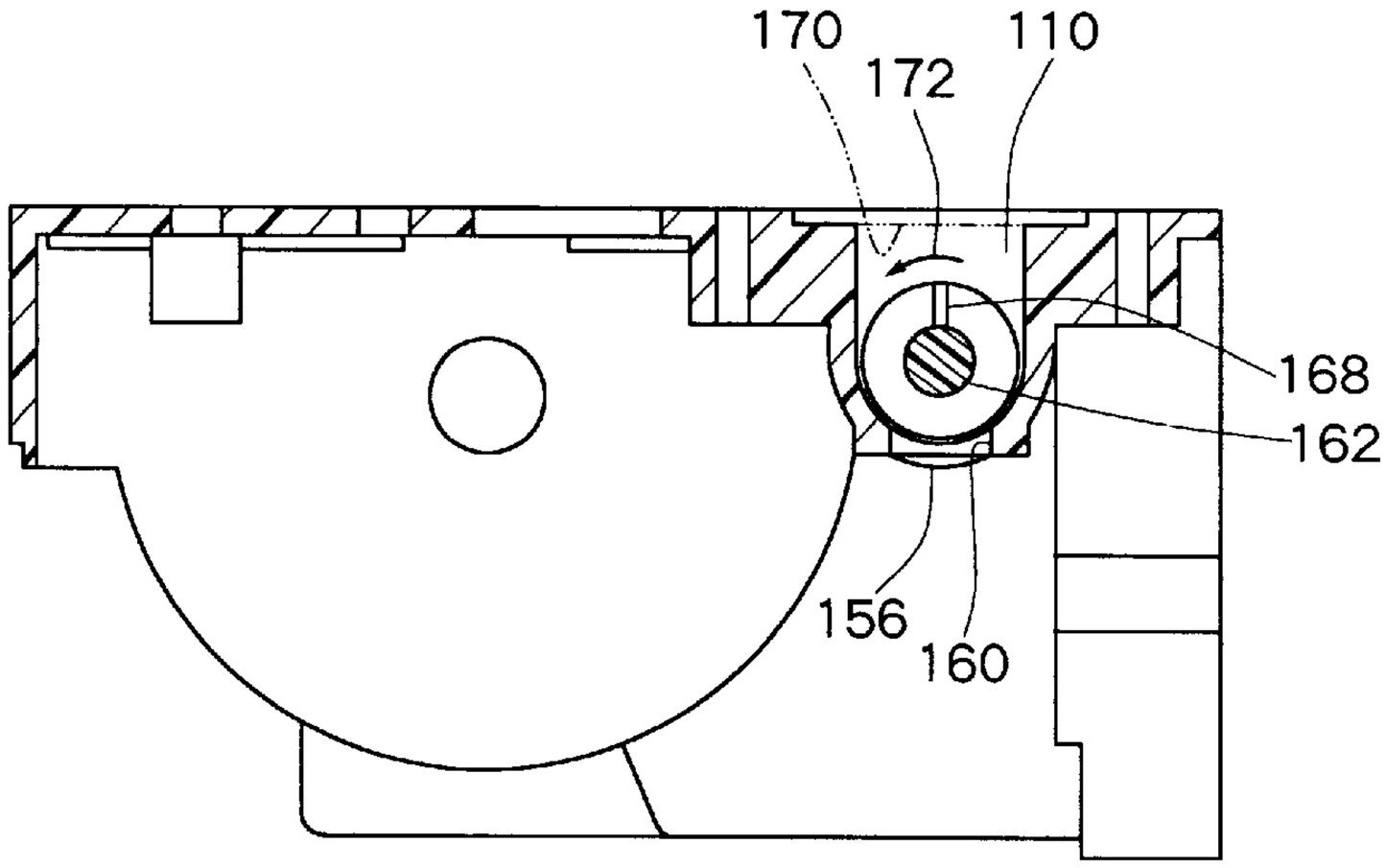


IMAGE FORMING MACHINE

FIELD OF THE INVENTION

This invention relates to a an image forming machine of the type in which a developing means, for developing a latent electrostatic image formed on an image bearing means into a toner image is equipped with a toner supply means for supplying to the developing means not only fresh toner, but also recycled toner that has been removed from the image bearing means.

DESCRIPTION OF THE PRIOR ART

In an electrostatic image forming machine, such as an electrostatic copier, a printer, or a facsimile machine, a latent electrostatic image is formed on an image bearing means, which may be a rotating drum having an electrostatic photoconductor disposed on the peripheral surface thereof. The latent electrostatic image on the image bearing means is developed to a toner image by a developing means. Then, the toner image on the image bearing means is transferred onto a sheet member, which may be a plain paper. Toner remaining on the image bearing means after transfer is removed from the image bearing means by a cleaning means.

The developing means applies developer containing toner onto the image bearing means to develop the latent electrostatic image on the image bearing means into a toner image. In the developing means, the toner is consumed as development proceeds, thus requiring that toner be supplied suitably to the developing means in the process of the development. Recently, as disclosed in Japanese Laid-Open Patent Publication No. 137561/80, it has been proposed to equip the developing means with a toner supply means for supplying the developing means not only with fresh toner, but also with recycled toner which has been removed from the image bearing means. An image forming machine with this type of toner supply means has found practical use.

In a conventional image forming machine, with a toner supply means for supplying a developing means not only with fresh toner but also with recycled toner removed from the image bearing means, the ratio between the fresh toner and the recycled toner in the toner supplied to the developing means is not controlled, thereby posing the following problems: The recycled toner, compared with the fresh toner, is deteriorated in at least some of its characteristics, such as charge characteristics. If the proportion of the recycled toner in the toner supplied to the developing means is too high, therefore, the quality of the toner image that is developed will be degraded, or the toner will excessively scatter in the developing zone. If the supply of the recycled toner to the developing means is overly restricted, the amount of the recycled toner that has been removed from the image bearing means, but has not been fed to the developing means, will become too large. As a result, there may be an overflow of the recycled toner from a recycled toner passageway or reservoir.

SUMMARY OF THE INVENTION

This invention has been made in the light of the foregoing facts. A principal object of the invention is to improve a toner supply means for supplying a developing means with recycled toner, removed from an image bearing means, along with fresh toner, thereby making-the ratio between fresh toner and recycled toner in the toner supplied to the developing means controllable in a desired range.

Another object of the invention is to attain the above object by a relatively simple construction without requiring a complicated, expensive structure.

To achieve the main object, the present invention disposes a toner supply means, of the type including a first toner acceptance region where fresh toner is introduced, a second toner acceptance region where recycled toner that has been removed from an image bearing means by a cleaning means is introduced, a toner discharge region where a toner discharge opening communicating with the developing means is formed, a first toner conveying means for conveying the fresh toner present in the first toner acceptance region to the toner discharge region, and a second toner conveying means for conveying the recycled toner present in the second toner acceptance region to the toner discharge region; wherein the ratio between the fresh toner and the recycled toner in the toner supplied to the developing means is defined by the amount of fresh toner conveyed by the first toner conveying means and the amount of recycled toner conveyed by the second toner conveying means.

That is, the present invention provides a image forming machine attaining the principal object, which is an image forming machine comprising an image bearing means, a latent electrostatic image forming means for forming a latent electrostatic image on the image bearing means, a developing means for developing the latent electrostatic image on the image bearing means to a toner image, a transfer means for transferring the toner image on the image bearing means onto a sheet member, a cleaning means for removing toner remaining on the image bearing means after transfer from the image bearing means, and a toner supply means for supplying toner to the developing means; wherein:

the toner supply means includes a first toner acceptance region where fresh toner is introduced, a second toner acceptance region where recycled toner that has been removed from the image bearing means by the cleaning means is introduced, a toner discharge region where a toner discharge opening communicating with the developing means is provided, a first toner conveying means for conveying fresh toner present in the first toner acceptance region to the toner discharge region, and a second toner conveying means for conveying recycled toner present in the second toner acceptance region to the toner discharge region, and

the ratio between the fresh toner and the recycled toner in the toner supplied to the developing means is defined by the amount of fresh toner conveyed by the first toner conveying means and the amount of recycled toner conveyed by the second toner conveying means.

Preferably, a toner passageway, extending substantially linearly, is formed in the toner supply means, the toner discharge region is defined at an intermediate part of the toner passageway, the first toner conveying means conveys fresh toner from one end to the intermediate part of the toner passageway, and the second toner conveying means conveys recycled toner from the other end to the intermediate part of the toner passageway. Preferably, a rotating shaft extends across the toner passageway, a first spiral blade is formed at one side part of the rotating shaft, a second spiral blade is formed at the other side part of the rotating shaft, the first spiral blade and the second spiral blade are wound in opposite directions, and the first spiral blade constitutes the first toner conveying means, while the second spiral blade constitutes the second toner conveying means. In a preferred embodiment, the toner passageway has substantially the same cross-sectional area throughout its lengthwise dimension, the outside diameter of the first spiral blade and

the outside diameter of the second spiral blade are substantially the same, and the ratio between the fresh toner and the recycled toner in the toner supplied to the developing means is defined by the ratio between the pitch of the first spiral blade and the pitch of the second spiral blade. The pitch of the first spiral blade and the pitch of the second spiral blade may be different from each other. In the toner supply means, it is preferred that there are formed a first toner acceptance chamber disposed along the one end of the toner passageway, and a second toner acceptance chamber disposed along the other end of the toner passageway. Preferably, the first toner acceptance chamber defines the first toner acceptance region, while the second toner acceptance chamber defines the second toner acceptance region. Preferably, the toner supply means includes a toner cartridge mounted detachably, and fresh toner in the toner cartridge is introduced into the first toner acceptance region.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a schematic sectional view of main constituent elements in an image forming machine constructed in accordance with the present invention;

FIG. **2** is an exploded perspective view of the main constituent elements in the image forming machine as shown in FIG. **1**;

FIG. **3** is a plan view of a toner supply means in the image forming machine shown in FIG. **1**;

FIG. **4** is a sectional view taken along line **4**—**4** of FIG. **3**;

FIG. **5** is a sectional view taken along line **5**—**5** of FIG. **3**; and

FIG. **6** is a sectional view taken along line **6**—**6** of FIG. **3**.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The present invention will now be described in detail with reference to the accompanying drawings illustrating preferred embodiments of an image forming machine constructed in accordance with the present invention.

FIG. **1** briefly shows main constituent elements in an image forming machine constructed in accordance with the present invention. The illustrated image forming machine has a rotating drum **2** constituting an image bearing means. On the peripheral surface of the rotating drum **2**, an electrostatic photoconductor **4** is disposed. Around the rotating drum **2**, which is to be rotated in the direction of an arrow **6**, a latent electrostatic image forming zone **8**, a developing zone **10**, a transfer zone **12**, and a cleaning zone **14** are disposed in this order. In the latent electrostatic image forming zone **8**, the surface of the electrostatic photoconductor **4** is uniformly charged to a specific polarity by the action of a charging corona discharger **16**. Then, as diagrammatically indicated by an arrow **18**, the electrostatic photoconductor **4** is exposed to light in accordance with an image to be formed, whereby a latent electrostatic image is formed on the electrostatic photoconductor **4**. In the developing zone **10**, a developer is applied onto the electrostatic photoconductor **4** by a developing means designated generally by the numeral **20**, whereby the latent electrostatic image is developed to a toner image. In the transfer zone **12**, the toner image on the electrostatic photoconductor **4** is transferred onto a sheet member (not shown) conveyed through the transfer zone **12**. On this occasion, a discharge current for transfer is applied by a transfer corona discharger **22** to the back of the sheet member, which may be a plain paper. In the cleaning zone **14**, toner remaining on the electrostatic photoconductor **4** after transfer is removed from the electrostatic photoconductor **4** by the action of a cleaning means indicated generally by the numeral **24**.

With further reference to FIG. **1**, the developing means **20** includes a development housing **26**. The development housing **26** includes a bottom wall **28** and a side wall **30** that are formed integrally. The two in the front-to-back direction of the development housing **26** (the direction perpendicular to the sheet surface of FIG. **1**) are closed by a front end wall **32** (see FIG. **2**) and a rear end wall **34**, respectively. Onto the top surface of the development housing **26**, a cover member **35** is joined. On the bottom wall **28**, two arcuate portions **36** and **38** are formed. Between the arcuate portions **36** and **38**, a substantially vertically upwardly extending partition wall **40** is formed. In the development housing **26**, the partition wall **40** separates a first developer passageway **42**, situated on one side of the partition wall **40**, and a second developer passageway **44**, situated on the other side of the partition wall **40**. The first developer passageway **42** and the second developer passageway **44** extend in the direction perpendicular to the sheet surface of FIG. **1**. The partition wall **40** does not exist in the opposite ends in the front-to-back direction of the development housing **26**, so that the first developer passageway **42** and the second developer passageway **44** communicate with each other at the front and rear ends of the development housing **26**. In the first developer passageway **42**, a first developer conveying means **46** is disposed, and in the second developer passageway **44**, a second developer conveying means **48** is disposed. The first developer conveying means **46** includes a spiral blade **52** rotationally driven in the direction of an arrow **50**, while the second developer conveying means **48** includes a spiral blade **56** rotationally driven in the direction of an arrow **54**.

In a left end in FIG. **1** of the development housing **26**, a developer applicator means **58** is disposed. This developer applicator means **58** is composed of a rotating sleeve member **62** which is rotationally driven in the direction of an arrow **60**, and a stationary permanent magnet member **64** placed in the sleeve member **62**. A part of the developer applicator means **58** protrudes outward through an opening formed between the bottom wall **28** and the cover member **35**. A free terminal edge of the cover member **35** is located in proximity to the outer peripheral surface of the sleeve member **62** to serve as a regulating means for regulating the thickness of a layer **66** of developer which is held on the outer peripheral surface of the sleeve member **62** and conveyed to the developing zone **10**. As will be seen by reference to FIG. **2** along with FIG. **1**, the arcuate portions **36** and **38** of the bottom wall **28**, and the side wall **30** extend outward of an upright support base plate **100** (to the lower left in FIG. **2**). An additional side wall (not shown) extending upward from one side edge of the arcuate portion **38** (the left side edge in FIG. **1**) is formed integrally with the above protrusions. Onto the top surface of the protrusions, an additional cover member **68** is joined. In the additional cover member **68**, a toner introduction opening **70** is formed. The first developer passageway **42** and the second developer passageway **44** extend into the protrusions, and the toner introduction opening **70** is positioned above the front end of the second developer passageway **44**. As shown clearly in FIG. **1**, an opening is formed in the arcuate portion **38** in the bottom wall **28** of the development housing **26**. This opening is fitted with a toner concentration detector **72**. The toner concentration detector **72** may be of a well known type which detects the permeability of the developer **66**.

In the developing means **20** as described above, a required amount of developer **66** is accommodated in the development housing **26**. The developer **66** contains carrier particles together with a toner. When the first developer conveying means **46** and the second developer conveying means **48** are rotationally driven, the developer **66** accommodated in the development housing **26** is conveyed rearward in the first developer passageway **42** as shown by an arrow **74** in FIG. **2**, and moved from the first developer passageway **42** to the second developer passageway **44** at the rear end of the development housing. Then, as shown by an arrow **76** in FIG. **2**, the developer **66** is conveyed forward in the second developer passageway **44**, and moved from the second developer passageway **44** to the first developer passageway **42** at the front end of the development housing **26**. During conveyance of the developer **66** through the first developer passageway **42** and the second developer passageway **44**, the toner and carrier particles are agitated and mixed, whereupon the toner is charged to a specific polarity. The developer applicator means **58** holds the developer **66** on the sleeve member **62** by the action of a magnetic field generated by the stationary permanent magnet member **64**. The developer **66** held on the sleeve member **62** is conveyed to the developing zone **10** in accordance with the rotation of the sleeve member **62**, and is applied to the electrostatic photoconductor **4** disposed on the peripheral surface of the rotating drum **2**. Thus, the latent electrostatic image on the electrostatic photoconductor **4** is developed to a toner image. As development proceeds, toner is consumed. When the toner concentration in the developer **66** becomes less than a predetermined value, the toner concentration detector **72** detects this. At this time, a toner supply means, to be described in detail later on, is actuated to supply toner into the development housing **26** through the toner introduction opening **70**.

Referring to FIG. **1**, cleaning means **24** includes a cleaning housing **78**. The cleaning housing **78** includes a bottom wall **80** and a side wall **82** that are formed integrally. Both ends in the front-to-back direction of the cleaning housing **78** (the direction perpendicular to the sheet surface of FIG. **1**) are closed by a front end wall and a rear end wall (not shown), respectively. Onto the top surface of the cleaning housing **78**, a cover member **84** is joined. In the cover member **84**, a protruding piece **86** is disposed which inclines slightly rightward and protrudes downward. To this protruding piece **86**, an upper end of a cleaning blade **88** is fixed. A free end of the cleaning blade **88**, which may be formed of synthetic rubber, is pressed against the electrostatic photoconductor **4** on the rotating drum **2**. To a front terminal edge of the bottom wall **80** of the cleaning housing **78**, i.e., the right terminal edge in FIG. **1**, a lower end part of a seal piece **90**, optionally formed of a plastic film, is fixed. This seal piece **90** extends upward, and its free end is brought into contact with the electrostatic photoconductor **4** on the rotating drum **2**. In a lower part of the cleaning housing **78**, a toner discharge means **92** is disposed. This toner discharge means **92** is composed of a spiral coil extending in the front-to-back direction. As will be mentioned further later on, the toner discharge means **92** extends forward through a discharge opening (not shown) formed in a front end wall (not shown) of the cleaning housing **78**. The toner discharge means **92** is rotationally driven in the direction of an arrow **94**.

In the above-described cleaning means **24**, the free end of the cleaning blade **88** acts on the electrostatic photoconductor **4** on the rotating drum **2** which is rotated in the direction of arrow **6**, thereby scraping the remaining toner off the electrostatic photoconductor **4**. The seal piece **90** prevents the scraped-off toner from scattering downward, out of the cleaning housing **78**. The fallen toner is collected in the lower part of the cleaning housing **78**. The toner discharge means **92**, rotationally driven in the direction of arrow **94**, conveys the toner forward, discharges it from the cleaning housing **78** through the discharge opening formed in the front end wall of the cleaning housing **78**, and introduces it into a second toner acceptance chamber in a toner supply means (to be described later on).

As will be seen by reference to FIG. **2** along with FIG. **1**, the rotating drum **2**, charging corona discharger **16**, developing means **20** and cleaning means **24** are combined as required, making up one unit **96**. Such a unit **96** is mounted at a predetermined position of a main housing (not shown) of an image forming machine. The transfer corona discharger **22** illustrated in FIG. **1** is mounted at a required position of the main housing separately from the unit **96**.

The above-described constitution of the illustrated image forming machine may be of a known type and does not constitute a novel feature in an image forming machine improved in accordance with the present invention. Thus, a more detailed description of the above constitution of the illustrated image forming machine is omitted in the present specification.

With further reference to FIG. **2**, the unit **96** also has a toner supply means, indicated generally by the numeral **98** and improved in accordance with the present invention. As clearly shown in FIG. **2**, the unit **96** includes an upright support base plate **100**, and the rotating drum **2** is mounted on the rear side of the support base plate **100**. The arcuate portions **36** and **38** of the bottom wall **20**, as well as the side wall **30**, in the developing means **20** protrude forward through a cutout formed in the support base plate **100**. The toner discharge means **92** in the cleaning means **24** extends forward through a short cylindrical body **102** extending through the support base plate **100**. The toner supply means **98** is situated on the front side of the support base plate **100**.

Referring to FIGS. **2** and **3**, the illustrated toner supply means **98** improved in accordance with the present invention includes a case **104**, which may be formed of a suitable plastic material. The case **104** is fixed to the support base plate **100**. In the case **104**, a first toner acceptance chamber **106**, a second toner acceptance chamber **108**, and a toner passageway **110** are formed. The first toner acceptance chamber **106** and the second toner acceptance chamber **108** are arranged in parallel. The toner passageway **110** extends linearly at the rear of the case **104**, one end of the toner passageway **110** extends adjacent the first toner acceptance chamber **106**, and the other end of the toner passageway **110** extends adjacent the second toner acceptance chamber **108**.

A reference to FIG. **4** along with FIGS. **2** and **3** shows that the first toner acceptance chamber **106** is relatively shallow. Its bottom wall, when viewed cross sectionally, has a nearly arcuately curved portion **112** and a substantially horizontally extending portion **114**. The rear of the first toner acceptance chamber **106** (to the right in FIG. **4**) directly communicates with one end of the toner passageway **110**. Such first toner acceptance chamber **106** defines a first toner acceptance region where fresh toner is introduced. On the case **104**, a toner cartridge mounting frame **116** is mounted to lie above the first toner acceptance chamber **106**. This frame **116** is of a nearly U-shape. On the frame **116**, a toner cartridge **118** (FIG. **4**) is mounted detachably. After the toner cartridge **118** is mounted on the frame **116**, a discharge port formed in the lower end surface of the toner cartridge **118** is unsealed.

Thus, fresh toner accommodated in the toner cartridge **118** is discharged into the first toner acceptance chamber **106**. The frame **116** and the toner cartridge **118** may themselves be of well known types, and so a detailed explanation for them is omitted herein.

Further referring to FIGS. **2** to **4**, a rotating shaft **120** extending substantially horizontally above the arcuate portion **112** of the bottom wall is mounted in the first toner acceptance chamber **106**. This rotating shaft **120** is drivingly connected via a suitable transmission element (not shown) to an electric motor **122**, which is mounted on one side surface of the case **104**. On the rotating shaft **120**, a moving member **124** of a nearly fan-shaped cross section is mounted for rotation. At one end of the rotating shaft **120**, a protruding piece **126** protrudes radially. On the other hand, a protruding piece **128** protrudes in the axial direction from one end surface in the axial direction of the moving member **124**. The position in the axial direction of the protruding piece **126** of the rotating shaft **120** is aligned with the position in the axial direction of the protruding piece **128** of the moving member **124**. At one side in the circumferential direction of the moving member **124**, a weight **130** is disposed. At another side in the circumferential direction of the moving member **124**, a permanent magnet **132** is disposed. On the front wall of the first toner acceptance chamber **106**, a magnetic sensor **134** is disposed. In the first toner acceptance chamber **106**, moreover, an elongated strip **136** extends in the axial direction above the horizontal portion **114** of the bottom wall and is mounted so as to be free to turn in a reciprocating manner between a first angular position indicated by a solid line and a second angular position indicated by a two-dot chain line in FIG. **4**. This strip **136** is also drivingly connected to the electric motor **122** via a suitable transmission element (not shown).

As will be further described later on, the electric motor **122** is energized, when the toner concentration detector **72** detects that the toner concentration in the developer **66** present in the development housing **26** of the developing means **20** has dropped below a predetermined value. Thus, the rotating shaft **120** is rotated in the direction of an arrow **138**, and the strip **136** is caused to turn in a reciprocating manner between the first angular position and the second angular position. The protruding piece **126** of the rotating shaft **120** contacts the protruding piece **128** of the moving member **124**. When the rotating shaft **120** is rotated in the direction of the arrow **138**, therefore, the moving member **124** is also rotated in the direction of arrow **138**. As seen by reference to FIG. **4**, when the moving member **124** is rotated in the direction of arrow **138**, the toner present on the arcuate portion **112** of the bottom wall is moved by the moving member **124** to the horizontal portion **114** of the bottom wall. The strip **136**, which is caused to turn in a reciprocating manner between the first and second angular positions, prevents the toner from solidifying in a lump on the horizontal portion **114** of the bottom wall. The strip **136** also moves the toner present on the horizontal portion **114** of the bottom wall into one side part of the toner passageway **110**, when the strip **136** is turned between the first angular position and the second angular position. When the toner concentration in the development housing **26** detected by the toner concentration detector **72** rises above a predetermined value, the electric motor **122** is deenergized at a time when the rotating shaft **120** comes to the angular position illustrated in FIG. **4**. When a sufficient amount of toner exists in the first toner acceptance chamber **106**, especially on the arcuate portion **112** of the bottom wall, the toner resists the rotation of the moving member **124**. Thus, the moving member **124** is rotated at a nearly constant rotational speed in accordance with the rotation of the rotating shaft **120**. As a result, the magnet **132** disposed, at another side in the circumferential direction of the moving member **124**, passes by the magnetic sensor **134** at a nearly constant rotational speed. When the toner in the toner cartridge **118** is substantially used up, and a sufficient amount of toner is not present on the arcuate portion **112** of the bottom wall, on the other hand, the resistance provided by the toner to the rotation of the moving member **124** decreases. In this case, the moving member **124** is rotated through about 120 degrees from the angular position shown in FIG. **4** in accordance with the rotation of the rotating shaft **120**. When the weight **130** disposed on the moving member **124** goes beyond its uppermost position, the moving member **124** is rotated rapidly to the position indicated by the solid line in FIG. **4**, because the center of gravity of the moving member **124** is eccentric owing to the weight **130**. As a result, the magnet **132**, disposed at the other side in the circumferential direction of the moving member **124**, passes by the magnetic sensor **134** at a high rotational speed. Consequently, the time interval from the time when the electric motor **122** is energized until the time when the magnetic sensor **134** detects the magnet **132** becomes relatively short. The toner supply means **98** is provided with a time measuring means (not shown) for measuring the time interval from the time when the electric motor **122** is energized until the time when the magnetic sensor **134** detects the magnet **132**. When this time interval falls short of a predetermined value, a signal is produced. Once this signal is produced, a lamp (not shown) is lit for showing that the toner cartridge **118** should be replaced by a fresh one.

A reference to FIG. **5** along with FIGS. **2** and **3** shows that the second toner acceptance chamber **108** is relatively shallow and has a bottom wall **139** which, in a cross sectional view, has a nearly semicircular shape. The rear of the second toner acceptance chamber **106** (to the right in FIG. **5**) communicates with the second end of the toner passageway **110**. Such second toner acceptance chamber **108** defines a second toner acceptance region where recycled toner discharged from the cleaning means **24** is introduced. As is seen by reference to FIGS. **3** and **5**, the second toner acceptance chamber **108** is provided with a cylindrical portion **140** which protrudes substantially horizontally rearward (upward in FIG. **3**, rightward in FIG. **5**) from a lower part of one side portion of the chamber **108**. In this cylindrical portion **140**, a recycled toner introduction passage communicating with the second toner acceptance chamber **108** is defined. The front end of the short cylindrical body **102** which is disposed in the support base plate **100** is inserted into the cylindrical portion **140**. Thus, the cleaning housing **78** of the cleaning means **24** communicates with the second toner acceptance chamber **108** via the short cylindrical body **102** and the cylindrical portion **140**. With reference to FIG. **1** as well, a front end of the toner discharge means **92**, which is disposed in the cleaning means **24** extends into the cylindrical portion **140** after passing through the short cylindrical body **102**. When the toner discharge means **92** is rotationally driven in the direction of arrow **94** in FIG. **1**, therefore, the toner in the cleaning housing **78** is discharged from the cleaning housing **78** and is introduced into the second toner acceptance chamber **108** via the short cylindrical body **102** and the cylindrical portion **140**.

Further referring to FIGS. **2**, **3** and **5**, a rotating shaft **142** extends substantially horizontally in the second toner acceptance chamber **108**. This rotating shaft **142** is drivingly

connected to the electric motor **122** via a suitable transmission element. (Such a transmission element includes a rotating shaft disposed in the toner passageway **110** and described later on.). On the rotating shaft **142**, a moving member **144** is formed integrally. The moving member **144** has four ribs **146** extending diametrically with spacing in the axial direction. Ribs **148** are connected to the two protruding ends of each of the four ribs **146** and extend in the axial direction. To each of the ribs **148**, a plastic film piece **150** is fixed. Each of the film pieces **150** extends from the rib **148** radially outward so as to be inclined in a direction opposite to the direction of rotation of the rotating shaft **142**, which is indicated by an arrow **152**. The moving member **144** further includes a plate-like piece **153** extending diametrically from one end of the rotating shaft **142**. The inward edge in the axial direction of the plate-like piece **153** is connected to one of the four ribs **148**. The plate-like piece **153** is situated above the cylindrical portion **140**. The top surface of the second toner acceptance chamber **108** is closed with a cover member **154** mounted on the top surface of the case **104**.

As stated previously, recycled toner discharged from the cleaning housing **78** of the cleaning means **24** is introduced into the second toner acceptance chamber **108**. When the electric motor **122** is energized, the rotating shaft **142** is rotationally driven in the direction of arrow **152**. Thus, the front edge of the film piece **150** rubs the bottom wall **138** to move the recycled toner present in the second toner acceptance chamber **108** into the toner passageway **110**. The plate-like piece **153** of the moving member **144** lifts the recycled toner introduced into the bottom part of the second toner acceptance chamber **108** through the cylindrical portion **140**.

A reference to FIG. **6** along with FIGS. **2** and **3** shows that the toner passageway **110** is relatively shallow and has a bottom wall **156** (see FIGS. **4** and **5**) which, in a cross sectional view, has a nearly semicircular shape. The linearly extending toner passageway **110** includes an intermediate portion **158** (FIG. **3**) lying between one end thereof extending along the first toner acceptance chamber **106** and the other end thereof extending along the second toner acceptance chamber **108**. This intermediate portion **158** defines a toner discharge region. In the intermediate portion **158**, a toner discharge opening **160** is formed in the bottom wall **156**. The toner discharge opening **160** is aligned with and positioned above the toner introduction opening **70** (FIG. **2**) of the developing means **20**.

In the toner passageway **110**, a rotating shaft **162** extends substantially horizontally. The rotating shaft **162** is drivingly connected to the electric motor **122** via a suitable transmission element (not shown). The rotating shaft **142** disposed in the second toner acceptance chamber **108** is drivingly connected to the rotating shaft **162** via a suitable transmission element (not shown). Thus, the rotating shaft **142** may be drivingly connected to the electric motor **122** via the rotating shaft **162**. On one end of the rotating shaft **162**, namely, the end extending along the first toner acceptance chamber **106**, a first spiral blade **164** is disposed. On the other end of the rotating shaft **162**, namely, the end extending along the second toner acceptance chamber **108**, a second spiral blade **166** is disposed. In the illustrated embodiment, the outside diameter of the first spiral blade **164** and the outside diameter of the second spiral blade **166** are substantially the same. However, the pitch Pa of the first spiral blade **164** and the pitch Pb of the second spiral blade **166** are different from each other, the pitches being set as Pb=2Pa. On an intermediate part of the rotating shaft **162**, i.e., the part located at the intermediate portion **158** of the toner passageway **110**, a paddle **168** is disposed. Paddle **168** is a plate-like piece protruding in the radial direction. The top surface of that one end of the toner passageway **110** which extends along the first toner acceptance chamber **106** is closed by the frame **116**. The top surface of the other end of the toner passageway **110** which extends along the second toner acceptance chamber **108** is closed by the cover member **154**. The top surface of the intermediate portion **158** of the toner passageway **110**, which defines the toner discharge region, is closed by a cover member **170** mounted on the top surface of the case **104**.

When the electric motor **122** is energized, the rotating shaft **162** is rotationally driven in the direction of an arrow **172**. Thus, the toner moved from the first toner acceptance chamber **106** to the one side part of the toner passageway **110** (such toner is fresh toner introduced from the toner cartridge **118** into the first toner acceptance chamber **106**) is conveyed to the intermediate portion **158** of the toner passageway **110** by the conveying action of the first spiral blade **164**. Simultaneously, the toner moved from the second toner acceptance chamber **108** to the other end of the toner passageway **110** (such toner is recycled toner introduced from the cleaning means **24** into the second toner acceptance chamber **108**) is conveyed to the intermediate portion **158** of the toner passageway **110** by the conveying action of the second spiral blade **166**. Hence, the first spiral blade **164** constitutes a first toner conveying means for conveying fresh toner, introduced into the first toner acceptance chamber **106**, to the toner discharge region defined by the intermediate portion **158** of the toner passageway **110**. Whereas the second spiral blade **166** constitutes a second toner conveying means for conveying recycled toner, introduced into the second toner acceptance chamber **108**, to the toner discharge region defined by the intermediate portion **158** of the toner passageway **110**. The fresh toner conveyed to the toner discharge region by the first spiral blade **164** and the recycle toner conveyed to the toner discharge region by the second spiral blade **166** are mixed together in the toner discharge region, discharged through the toner discharge opening **160**, and supplied to the developing means **20** through the toner introduction opening **70** (FIG. **2**). The paddle **168** disposed on the rotating shaft **162** moves the toner, conveyed to the toner discharge region, toward the toner discharge opening **160**, promoting the discharge of the toner through the toner discharge opening **160**.

The action of the toner supply means **98** will be summarized as follows: When the toner concentration detector **72** detects that the toner concentration in the developer **66** present in the development housing **26** has fallen below a predetermined value, the electric motor **122** is energized. Thus, the rotating shaft **162** is rotationally driven in the direction of arrow **172**, and fresh toner present in the one end of the toner passageway **110** is conveyed to the toner discharge region by the first spiral blade **164**. At the same time, recycled toner present in the other end of the toner passageway **110** is conveyed to the toner discharge region by the second spiral blade **166**. This fresh toner and recycled toner are mixed together and supplied to the development housing **26** through the toner discharge opening **160** and the toner introduction opening **70**. Simultaneously, fresh toner present in the first toner acceptance chamber **106** is moved to the one end of the toner passageway **110** by the moving member **124**, which is rotated in the direction of arrow **138**, and the strip **136** is turned in a reciprocating manner. On the other hand, recycled toner present in the second toner acceptance chamber **108** is moved to the other end of the

toner passageway **110** by the moving member **144** which is rotated in the direction of arrow **152**.

Assume that a sufficient amount of fresh toner is present in the first toner acceptance chamber **106**, and a sufficient amount of fresh toner is moved to the one end of the toner passageway **110**, while a sufficient amount of recycled toner is present in the second toner acceptance chamber **108**, and a sufficient amount of recycled toner is moved to the other end of the toner passageway **110**. As long as these conditions are fulfilled, the ratio between fresh toner and recycled toner in the toner discharged through the toner discharge opening **160**, and thus the toner introduced into the developing means **20** through the toner introduction opening **70**, is defined by the amount of fresh toner conveyed to the toner discharge region by the first spiral blade **164** and the amount of recycled toner conveyed to the toner discharge region by the second spiral blade **166**. In the illustrated embodiment, the first spiral blade **164** and the second spiral blade **166** are disposed on the common rotating shaft **162**, so that the number of revolutions of the first spiral blade **164** and the number of revolutions of the second spiral blade **166** are the same. As mentioned previously, the outside diameter of the first spiral blade **164** and the outside diameter of the second spiral blade **166** are also substantially the same. Thus, the ratio between the amount of conveyance by the first spiral blade **164** and the amount of conveyance by the second spiral blade **166** is defined by the pitch Pa of the first spiral blade **164** and the pitch Pb of the second spiral blade **166**. This ratio is 1:2. That is, in the illustrated embodiment, the ratio between fresh toner and recycled toner in the toner supplied to the developing means **20** is 1:2. This ratio between fresh toner and recycled toner in the toner supplied to the developing means **20** can be suitably set depending on the volume of the second toner acceptance chamber **108** where recycled toner is introduced, the quality of development by the developing means **20**, and so on. If the proportion of recycled toner in the toner supplied to the developing means **20** is decreased excessively, unacceptable performance will occur, in that toner will overflow from the second toner acceptance chamber **108**, the cleaning housing **78** (FIG. **1**), or the short cylindrical body **102** and cylindrical portion **140** which connect together the cleaning housing **78** and the second toner acceptance chamber **108**. If the proportion of recycled toner in the toner supplied to the developing means **20** is increased excessively, on the other hand, the quality of development by the developing means **20** will overly decline. In the illustrated embodiment, the first spiral blade **164** and the second spiral blade **166** are disposed on common rotating shaft **162**. If desired, however, the first spiral blade **164** and the second spiral blade **166** may be disposed on separate rotating shafts. In this case, the numbers of revolutions of the respective rotating shafts may be set suitably to adjust the ratio between the amount of fresh toner conveyed by the first spiral blade **164** and the amount of recycled toner conveyed by the second spiral blade **166**.

The preferred embodiments of the image forming machine constructed in accordance with the present invention have been described in detail by reference to the accompanying drawings. It is to be understood, however, that the present invention is in no way restricted to these embodiments, and various changes and modifications may be made without departing from the spirit and scope of the invention.

What we claim is:

1. An image forming machine comprising image bearing means, latent electrostatic image forming means for forming a latent electrostatic image on the image bearing means, developing means for developing the latent electrostatic image on the image bearing means to a toner image, transfer means for transferring the toner image on the image bearing means onto a sheet member, cleaning means for removing toner, remaining on the image bearing means after transfer, from the image bearing means, and toner supply means for supplying toner to the developing means; wherein:

the toner supply means includes means defining a substantially linearly extending toner passageway, means defining a first toner acceptance region at a first end of the toner passageway into which fresh toner is introduced, means defining a second toner acceptance region at a second end of the toner passageway into which recycled toner, that has been removed from the image bearing means by the cleaning means, is introduced, means defining a toner discharge region at an intermediate point in the discharge passageway and having a toner discharge opening communicating with the developing means, a first toner conveying means for conveying fresh toner from the first toner acceptance region to the toner discharge region, and a second toner conveying means for conveying recycled toner from the second toner acceptance region to the toner discharge region.

2. The image forming machine of claim **1**, wherein:

the toner supply means further includes a rotating shaft extending across the toner passageway;

the first toner conveying means comprises a first spiral blade formed on a first end of the rotating shaft,

the second toner conveying means comprises a second spiral blade formed on a second end of the rotating shaft, and

the first spiral blade and the second spiral blade are wound in opposite directions.

3. The image forming machine of claim **2**, wherein:

the toner passageway has substantially the same cross-sectional area throughout its lengthwise dimension,

the outside diameter of the first spiral blade and the outside diameter of the second spiral blade are substantially the same, and

the ratio between the pitch of the first spiral blade and the pitch of the second spiral blade defines the ratio between the fresh toner and the recycled toner supplied to the developing means.

4. The image forming machine of claim **3**, wherein the pitch of the first spiral blade and the pitch of the second spiral blade are different from each other.

5. The image forming machine of claim **1**, wherein the first toner acceptance region comprises a first toner acceptance chamber disposed along the first end of the toner passageway, and the second toner acceptance region comprises a second toner acceptance chamber disposed along the second end of the toner passageway.

6. The image forming machine of claim **1**, wherein the toner supply means further includes a detachably mounted toner cartridge for introducing fresh toner into the first toner acceptance region.

* * * * *